Problem Statement and Goals
RoCam

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Table 1: Revision History

Date	**Developer(s)**	**Change**
Sept. 8, 2025	Jianqing Liu	Initial Draft
Sept. 9, 2025	Zifan Si	Details Elaboration
Sept. 10, 2025	Zifan Si	Fix based on teammate suggestion
...	...	...

1 Problem Statement

[You should check your problem statement with the problem statement checklist. —SS]

[You can change the section headings, as long as you include the required information. —SS]

1.1 Problem

In model rocketry, two of the hardest engineering problems are staging failures and parachute tangling. These problems are hard to study because they happen in mid-flight, where direct observation is limited. Without reliable tracking, engineers cannot fully understand these failures or design better solutions. As a result, recurring issues remain unresolved, slowing progress in both safety and performance of future rockets.

Model rockets travel at very high speeds, sometimes faster than Mach 3 and over 100 km in altitude (TODO: citation). Under these conditions, manual camera tracking is not possible.

Tracking a small model rocket is even harder than tracking large rockets such as the Falcon 9. Smaller size and uncontrolled launch conditions make accurate detection and continuous tracking much more difficult.

Some commercial tracking systems exist (TODO: citation), but they do not have the accuracy or speed needed to follow small, fast-moving rockets. This gap shows the need for a dedicated system that can provide clear, real-time observation of rocket flights.

1.2 Inputs and Outputs

- **Inputs**
  - 1080p 60fps camera feed of a rocket
  - Basic system state information for tracking
- **Outputs**
  - Camera orientation adjustments to maintain object lock
  - Stabilized video stream with the object centered in frame
  - User interface for monitoring and control

1.3 Stakeholders

Direct Stakeholders

1. **McMaster Rocketry Team**: The primary end users who will deploy the system during launches. They depend on accurate real-time tracking to analyze staging, parachute deployment, and overall flight performance.
2. **Dr. Shahin Sirouspour (Supervisor)**: Provides technical guidance, project oversight, and mentorship. Ensures the project aligns with academic standards, engineering best practices, and capstone deliverable expectations.

Indirect Stakeholders

1. **Aerospace Engineers and Researchers**: Benefit from high-quality flight footage to validate models, improve rocket designs, and support experimental research.
2. **Event Organizers and Safety Officers**: Rely on reliable tracking for live monitoring of rocket flights, particularly for confirming parachute deployment and safe recovery during launch events.
3. **Engineering and Robotics Community**: May adapt the system's design principles for other domains requiring precise tracking of fast-moving objects, such as UAV navigation, sports analytics, or autonomous robotics.

4. **Potential Commercial and Industrial Users**: Could adopt the system for broader applications in surveillance, wildlife monitoring, or industrial inspections where real-time vision-guided tracking is valuable.

1.4 Environment

Development Frameworks and Tools:

1. *GitLab* will be used for version control, project management, and CI/CD pipelines to automate testing and deployment.
2. *Visual Studio Code* will serve as the primary IDE for software development across the embedded system, computer vision pipeline, and web application components.
3. *GitHub Actions* (or GitLab CI) will provide automated unit/integration testing and continuous integration workflows for reliable code validation.
4. *NVIDIA Jetson Orin Nano SDK* will be used for computer vision model execution, GPU acceleration, and performance optimization.
5. *STM32 Development Tools* (STM32CubeIDE, OpenOCD, or equivalent) will support programming and debugging of the embedded gimbal motion controller.

1.5 Gimbal

An off-the-shelf cheap gimbal is used.

A custom developed PCB is used to adapt the gimbal to the Jetson.

1.6 Computer Vision

Nvidia Jetson Orin Nano Super

1.7 Web Management Portal

Runs on any recent web browser

2 Goals

Track small-scale rocket launches (apogee ¡ 200m)

3 Stretch Goals

connected to a full-size gimbal developed by the McMaster Rocketry Team to track high-powered rocket launches (apogee 3km+)

4 Extras

[Teams may wish to include extras as either potential bonus grades, or to make up for a less advanced challenge level. Potential extras include usability testing, code walkthroughs, user documentation, formal proof, GenderMag personas, Design Thinking, etc. Normally the maximum number of extras will be two. Approval of the extras will be part of the discussion with the instructor for approving the project. The extras, with the approval (or request) of the instructor, can be modified over the course of the term. —SS]

4.1 Circuit Design

4.2 TODO: Extra 2

Appendix — Reflection

[Not required for CAS 741 —SS]

The purpose of reflection questions is to give you a chance to assess your own learning and that of your group as a whole, and to find ways to improve in the future. Reflection is an important part of the learning process. Reflection is also an essential component of a successful software development process.

Reflections are most interesting and useful when they're honest, even if the stories they tell are imperfect. You will be marked based on your depth of thought and analysis, and not based on the content of the reflections themselves. Thus, for full marks we encourage you to answer openly and honestly and to avoid simply writing "what you think the evaluator wants to hear."

Please answer the following questions. Some questions can be answered on the team level, but where appropriate, each team member should write their own response:

1. What went well while writing this deliverable?

2. What pain points did you experience during this deliverable, and how did you resolve them?

3. How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?